Condition monitoring of a fixed railway crossing

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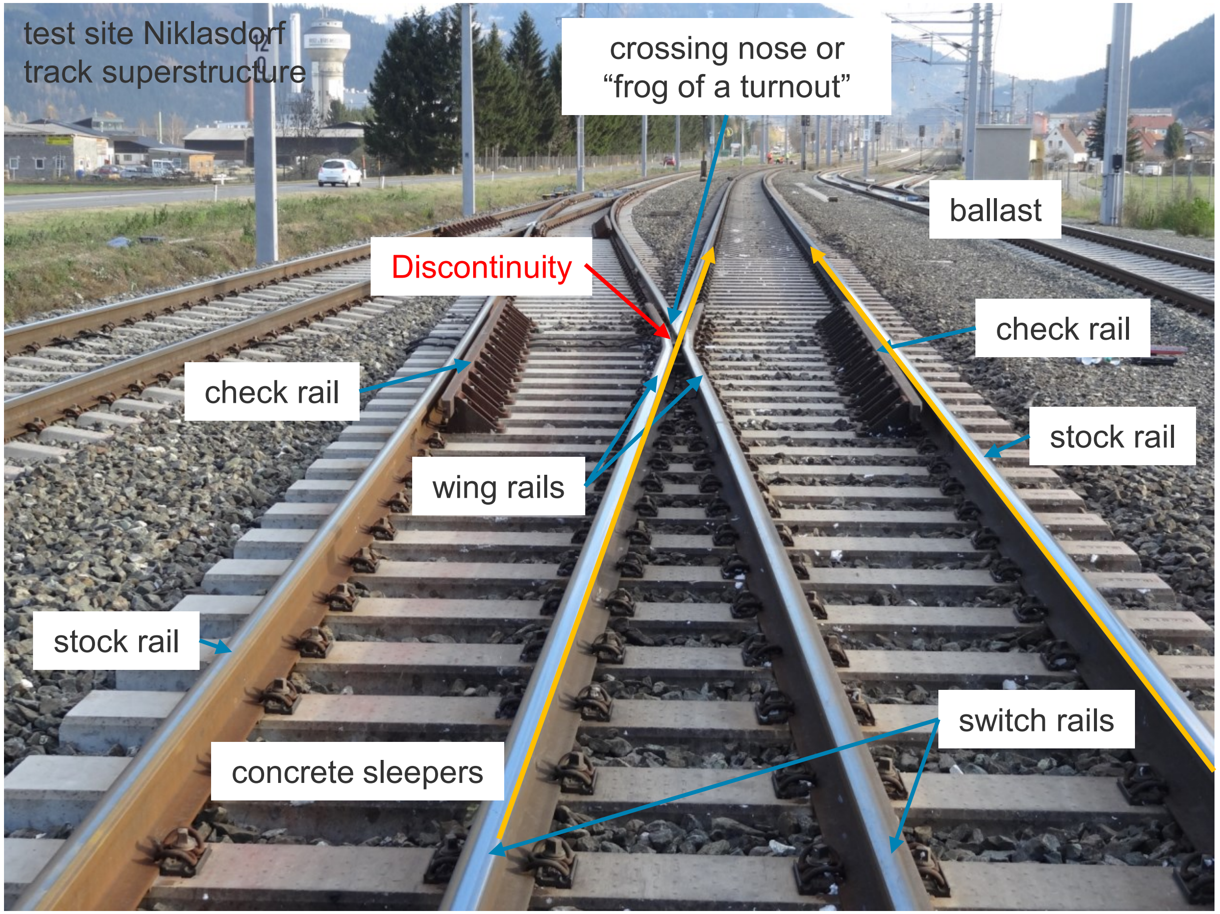
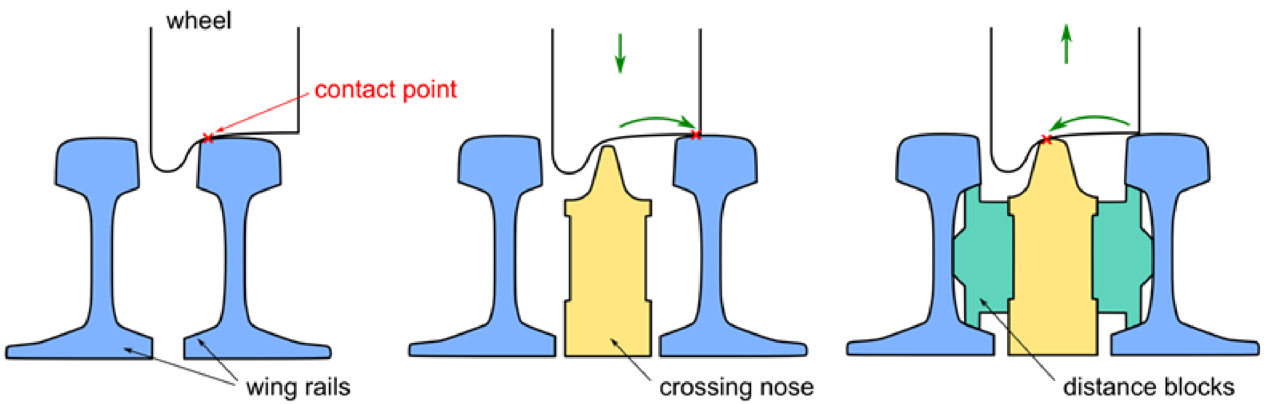
Introduction



Introduction

- Transition of a wheel over a turnout crossing



- Slip, due to different rolling radii
- High vertical forces as a result of vertical wheel movement

Material response to loading

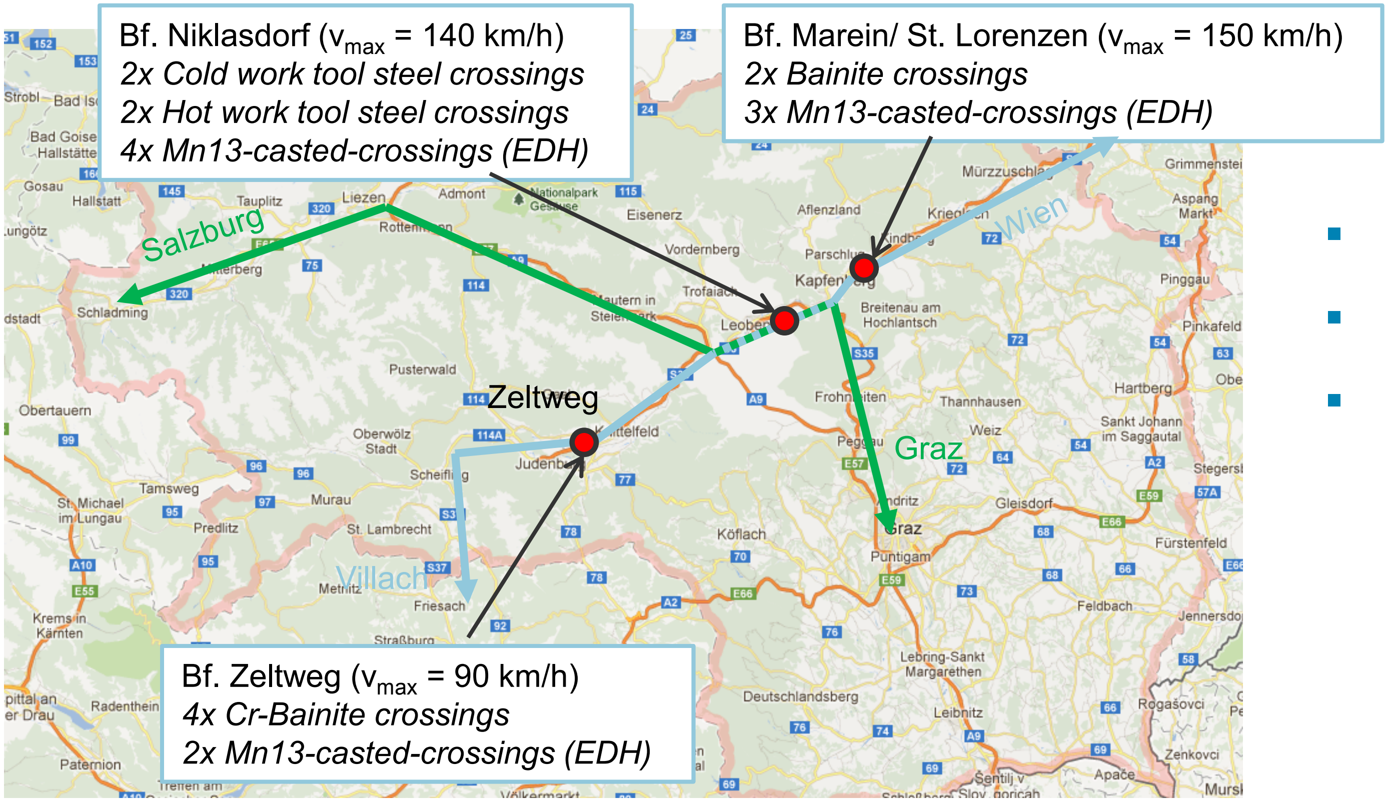
- Plastic deformation

- Wear

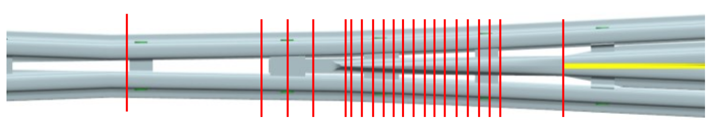
- Rolling contact fatigue

- All three material responses demand for maintenance or replacement of the crossing after some time.

Field trials
geometry measurements



- ∑ 20 turnouts
- 60E1–500m–1:12
- 5 different materials



Measured cross-sections

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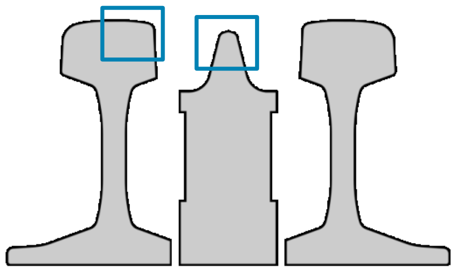
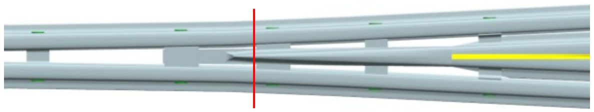
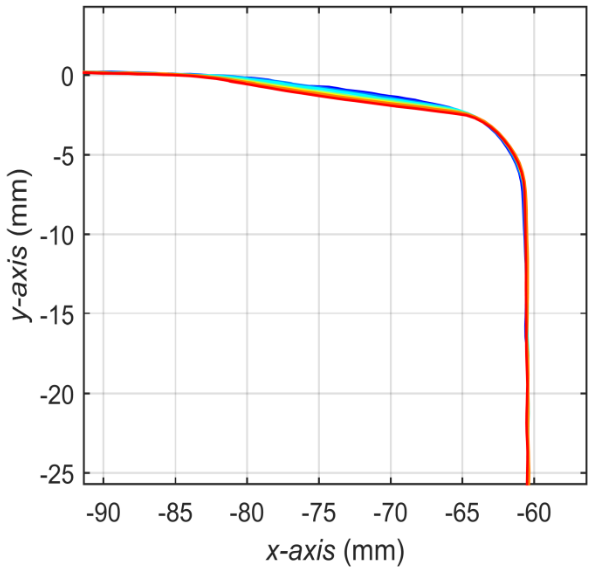
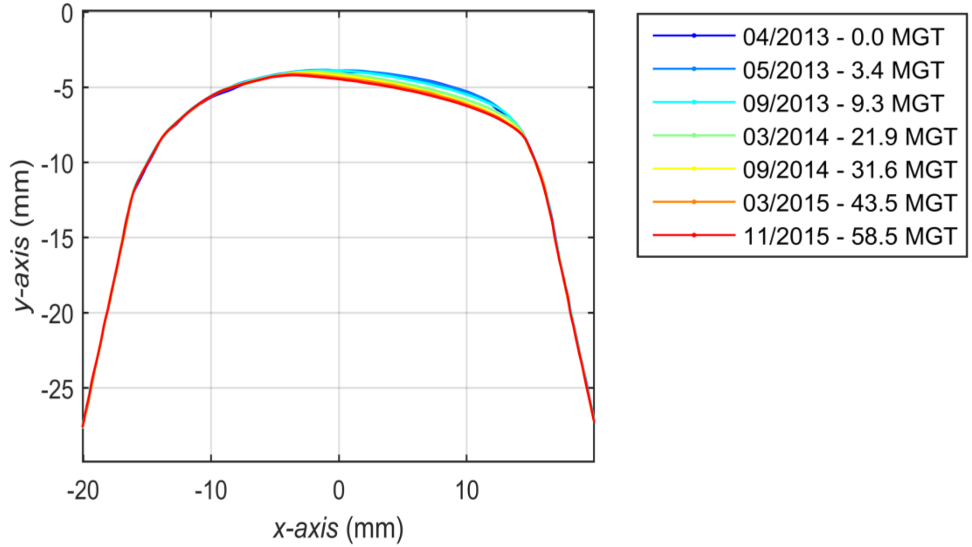
Geometry measurements

- 2d cross-section evaluation



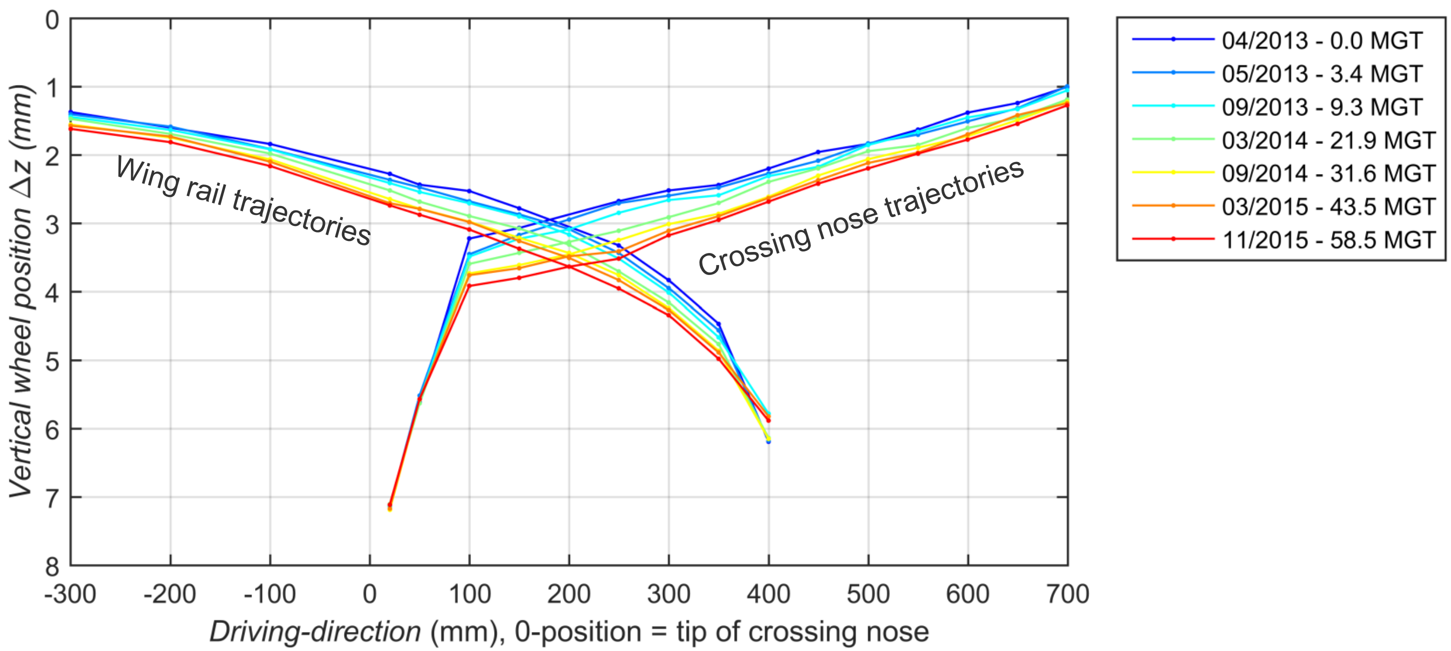






Geometry measurements

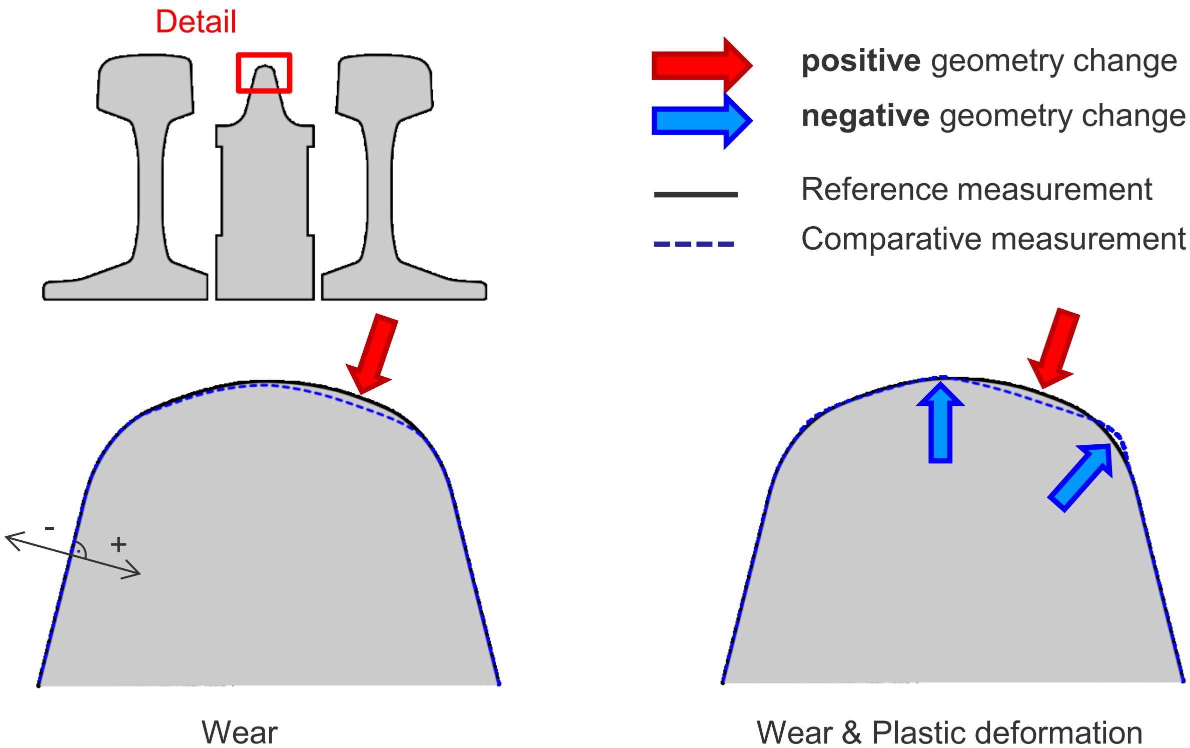
- Vertical wheel position trajectories (ORE-S1002 wheel, y=0)



- Low changes of transition geometry
- Transition point moves slightly to end of crossing

Field trials
geometry measurements

- Geometry change calculation of geometry measurements

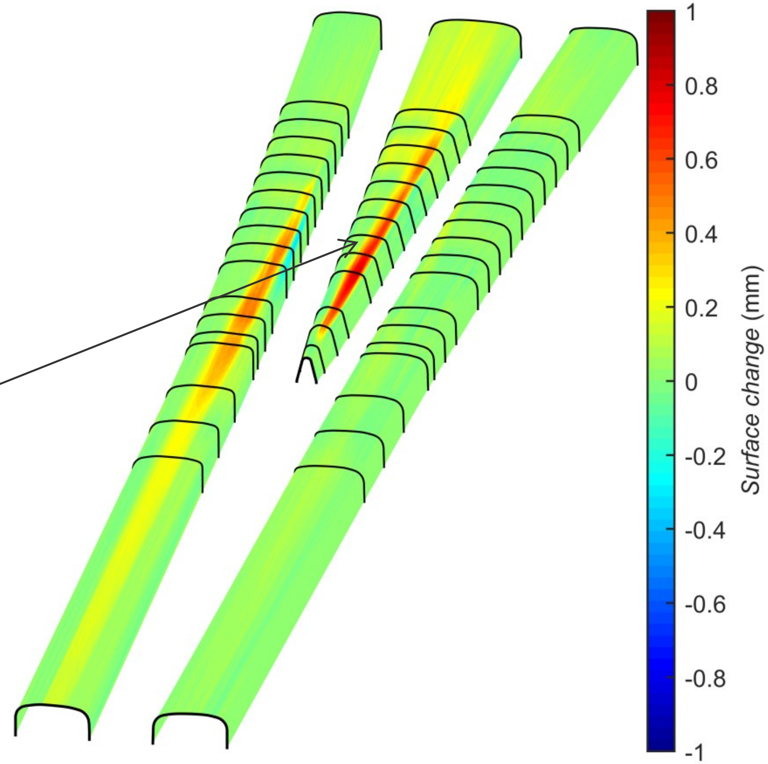


- Negative surface change is always related to macroscopic plastic deformation

Field trials,
Results for cold work tool steel

Cold work tool steel:
Niklasdorf

Surface change through wear at very low values



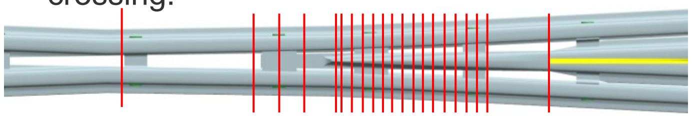
43,6 MGT
Pre: 0.0 MGT

- Moderate RCF performance, low wear rate, no deformation.
- Material is very sensitive concerning manufactured geometry, because it changes its geometry very slow.

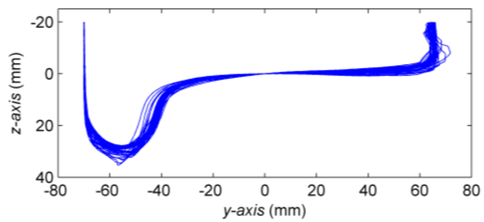
Geometry assessment: Methodology

Geometry measurements

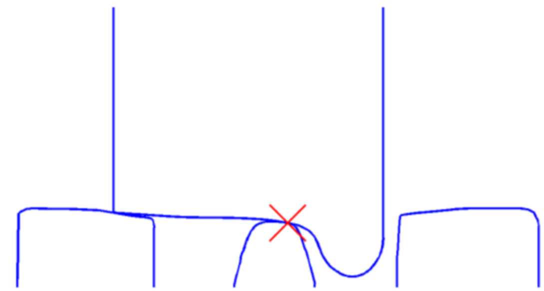
crossing:



Wheel profiles

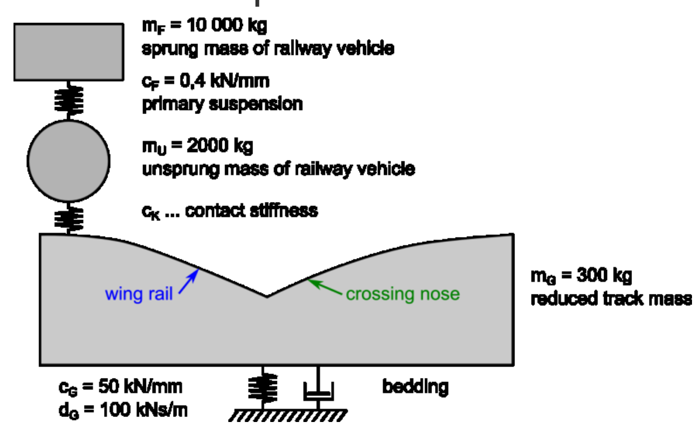


Contact calculation

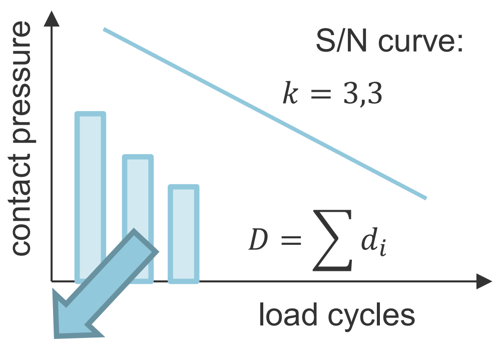


Hertzian pressure

Simple MBS-model

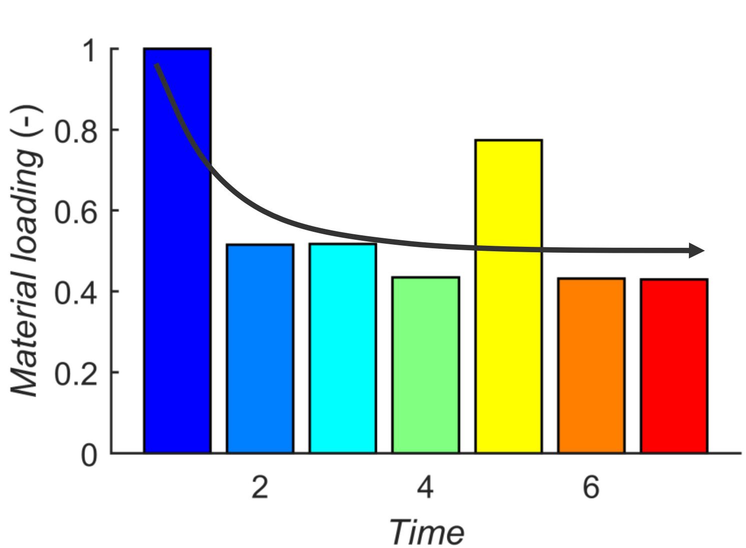


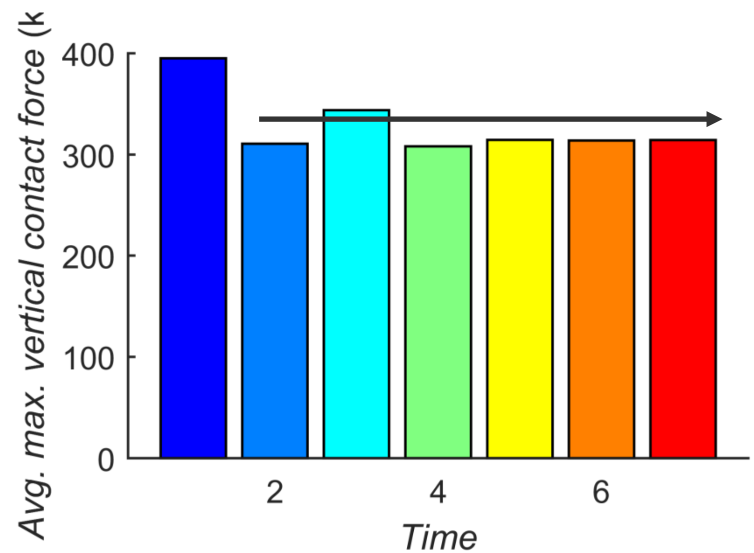
Simple assessment model



Material loading

Geometry assessment:
Evolution of loading for cold work tool steel





- Geometry adaption process leads to lower material loading while contact forces stay almost constant.
- All different crossing nose materials show this self-optimization process

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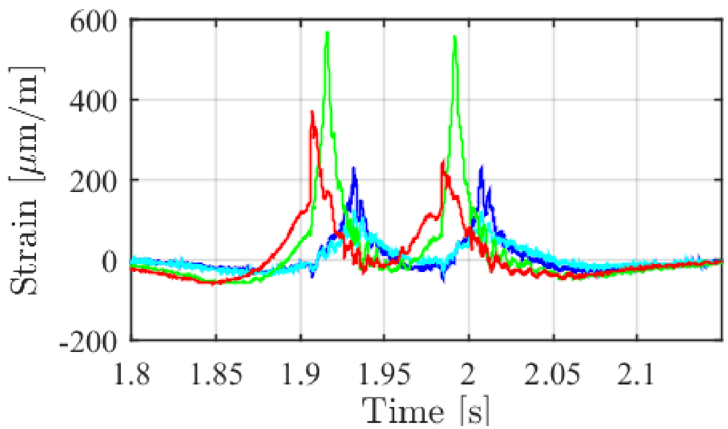
Measurement equipment

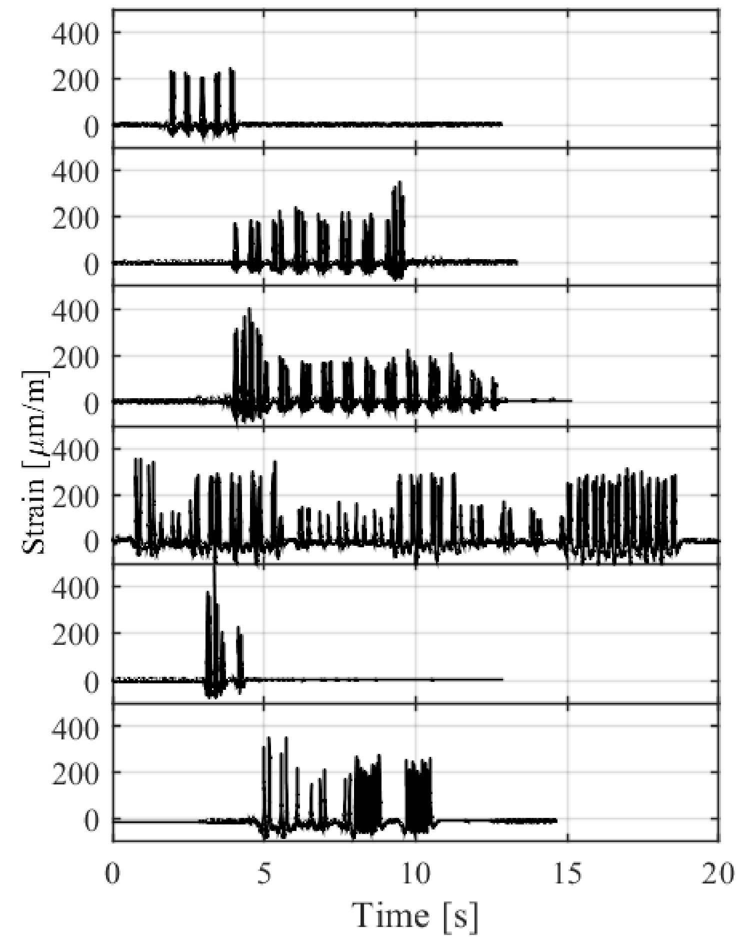
- Strain gauge application before turnout installation

- 4 channels, measure bending strain of crossing nose structure

Strain measurements

Figure: 4 DMS channels, two axles



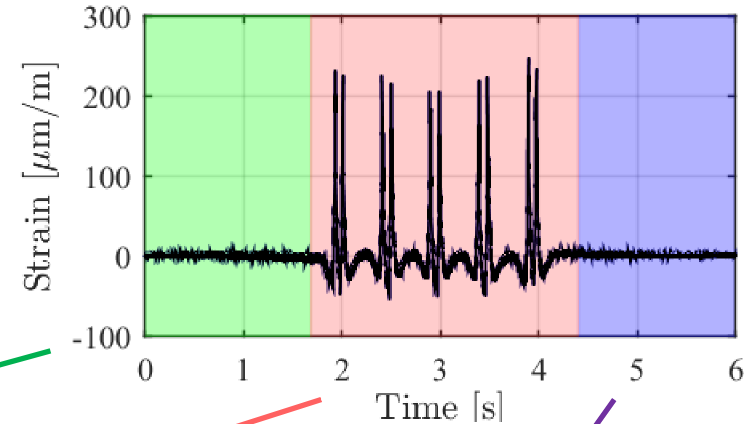


- The 4 strain channels show a typical pattern that is commonly known as *“Winkler foundation”*
- Different trains (with diff. axle distances & axle loads) show a different characteristic pattern.

Strain measurements

- Trains with invariant configurations, like Bombardier „*Talent*“ are evaluated:

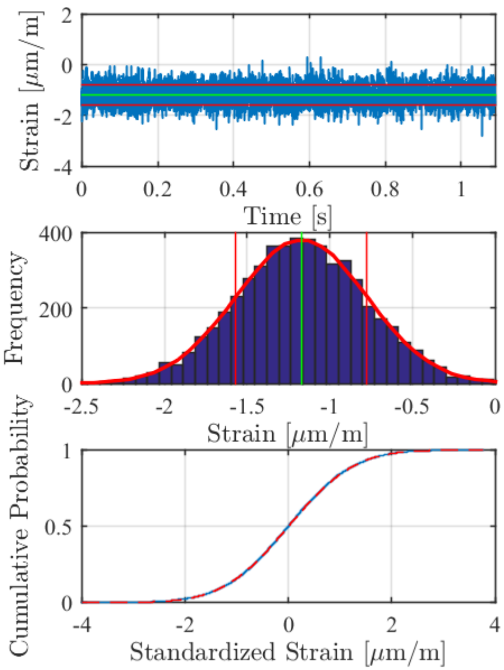
Resource: wikipedia.org



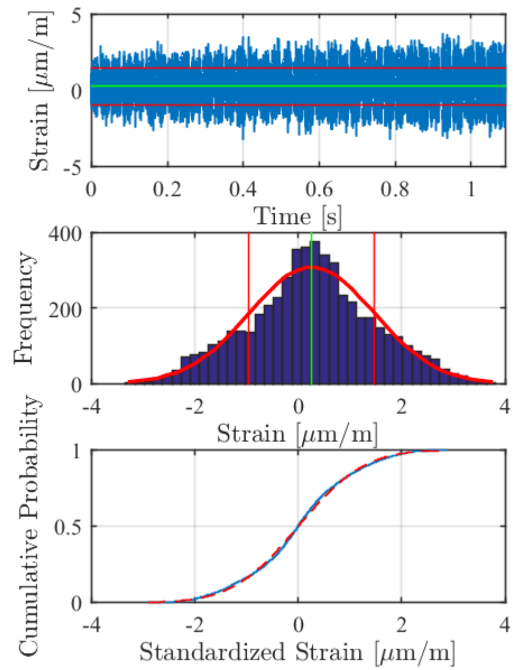
- Noise evaluation: *Kolmogorov-Smirnov-Test* to detect good wheels / bad wheels
- Pattern evaluation: Dynamic-time-warping and resampling to visualize changes in the load pattern.
- Offset evaluation: Residual strain

Noise evaluation: Kolmogorov-Smirnov-Test

- Calculation of probability distribution and cumulative probability distribution:



Good wheel

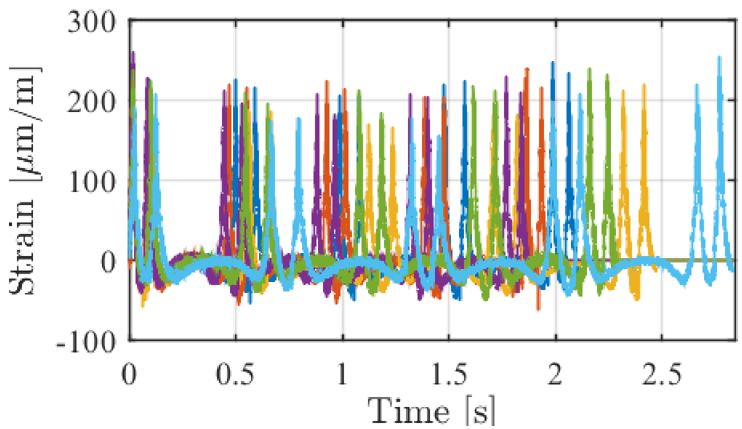


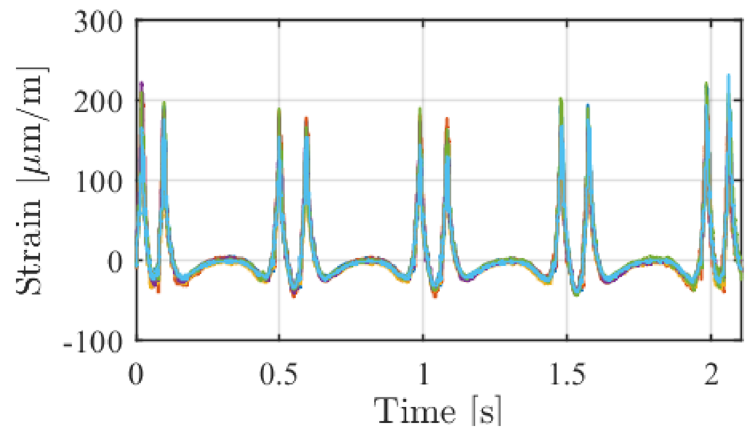
Bad wheel

- The test is based on the fact that random noise usually follows Gaussian distribution => Spectral analysis follows

Pattern evaluation

- For pattern comparison, as train speeds are not exactly equal every time, dynamic-time-warping is used:





Minimize: $$E = \int \{r(t) - s(g(t))\} \cdot dt$$

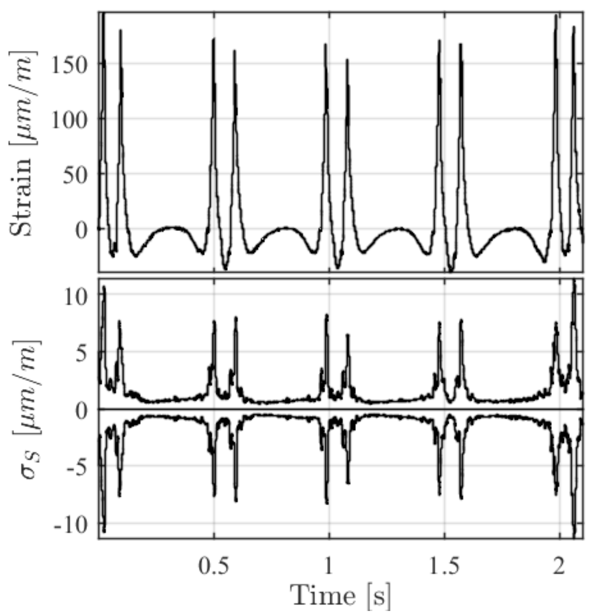
Reference signal — Measurement signal

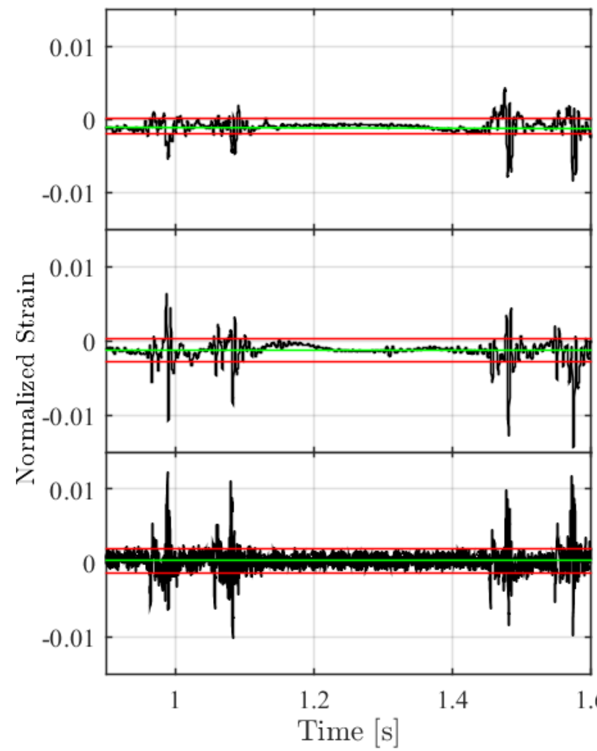
$$g(t) = c_2 \cdot t^2 + c_1 \cdot t + c_0$$

- After dynamic-time-warping the signals are resampled to guarantee a uniform sampling interval and equal number of samples.

Pattern evaluation

- Strain pattern normalisation and subtraction (to visualize the change):





- A characteristic change of load patterns was observed which can be, e.g. a result of ballast or impact change.

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Conclusion

- Numerical methods to evaluate geometry measurements and strain measurements were developed and presented.
- Geometry changes due to deformation, wear or breakouts change the material loading of a fixed crossing.
- Strain measurements can give an information how the loading changes over time and we can detect “bad” wheels.
- Our target: In the future we want to create forecast models based on the gained data to predict damage and initiate maintenance actions dynamically.

Thank you!

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Preceding publications

U. Oßberger, M. Pletz, S. Eck, W. Daves, H. Oßberger:
Validation of a finite element crossing model using measurements at an instrumented turnout,
Proceeding of the 23rd International Symposium on Dynamics of Vehicels on Roads and Tracks, 19-23. August **2013**, Qingdao, China, paper No. 32.2

S. Eck, H. Oßberger, U. Oßberger, S. Marsoner, R. Ebner:
Comparison of the fatigue and impact fracture behaviour of 5 different steel grades used in the frog of a turnout,
Int. J. Rail and Rapid Transit 228 (6) **2014**, pp 603-610

U. Oßberger, S. Eck and E. Stocker:
Performance of different materials in a frog of a turnout,
Proceedings of the 11th International Heavy Haul Conference, 21-24 June, **2015**, Perth, Australia, 329-336.

W. Kollment, P. O'Leary, M.Harker, U. Oßberger and S. Eck:
Towards Condition Monitoring of Railway Points: Instrumentation, Measurement and Signal Processing,
Proceedings of IEEE International Instrumentation and Measurement Technology Conference (I2MTC), 23-26 May **2016**, Taipei, Taiwan, pp. 612-617

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